

WORKPLACE SOLUTIONS

From the National Institute for Occupational Safety and Health

Reducing Illnesses at Indoor Waterparks

Summary

Lifeguards and patrons in the rapidly growing indoor waterpark industry can be exposed to numerous disinfection byproducts (DBP) and microorganisms that can cause adverse health effects such as eye and respiratory irritation, skin rashes, and flu-like symptoms. NIOSH provided technical assistance to a county health department to investigate the cause of symptoms reported by employees of a large indoor waterpark. This document addresses issues that pool managers, designers, and public health officials should consider to reduce illness at indoor water parks.

Description of Exposure

The mixture of disinfectants, such as chlorine, and compounds found in pool water can produce many DBPs, which can dissipate into the air; microorganisms may also be present in water and can make people sick. Also, indoor waterparks have many splash and spray features that can aerosolize contaminants from the water into the air, where patrons and employees

can inhale them (see Figures 1 and 2). These features can make managing this environment more difficult than in still-water pools.

Waterparks can have high numbers of patrons, including young children, spending long lengths of time in the waterpark area, which can be a major contributing factor to DBP production because they produce sweat and urine. The average amount of urine, which contains nitrogenous compounds, released into pool waters per bather is 25 to 30 milliliters [Gunkel and Jessen 1988], and each liter of sweat contains one gram of nitrogen [WHO 2006]. As more sweat and urine are released into the pool water, the nitrogen-containing compounds also increase which can chemically mix with disinfectants to create irritating DBPs in the air.

Lifeguards and employees working inside an enclosed waterpark for long durations may be at higher risk of having symptoms of exposure to DBPs because they work long hours with fewer breaks than those who work outside the enclosed area.

Chloramines and Endotoxins

Chloramines are DBPs that form when chlorine combines with nitrogen-containing compounds from sweat or

urine. Chloramines, specifically trichloramine, are suspected as a primary cause of reported irritation symptoms based on exposure monitoring studies [Hery et al. 1995; Massin et al. 1998]. People exposed to trichloramine may experience respiratory symptoms such as cough, chest tightness, wheezing, and eye irritation. In addition to the number of people using the pool, other factors that affect the chloramine concentration in indoor waterparks include water chemistry parameters (e.g., chlorine concentration, pH, temperature), aerosolization of particles caused by splashing and spraying, and air recirculation from the ventilation system [Hery et al. 1995; Massin et al. 1998].

Endotoxin, which is found in the cell wall of certain bacteria, is released when the bacterial cell breaks down or multiplies. It has been found in various industrial and nonindustrial settings associated with bacterial contamination, humidifiers, air conditioners, and other water-associated processes. It can cause airway and alveolar inflammation as well as chest tightness, fever, and malaise and acute reduction in lung function.

Case Study

NIOSH assisted a local health department to investigate eye and respiratory



Figures 1 and 2. Aerosolizing spray features of waterpark.

irritation symptoms at an indoor waterpark resort. This waterpark was newly opened, and within a month, the county health department received about 80 reports of eye and respiratory irritation from patrons and employees. Symptoms included red, burning or itchy eyes; itchy or runny nose; cough; wheezing; shortness of breath; chest tightness; or sore throat. Initial tests revealed normal water chemistry as well as air chlorine concentrations below NIOSH and OSHA occupational exposure limits. Management added supply diffusers to the ventilation system to increase air movement at the deck level, increased the frequency of water chemistry checks, and added more fresh water to all systems to reduce symptom reports; however, the county health department continued to receive health complaints prompting a technical assistance request to NIOSH. Because the NIOSH mission is to promote occupational safety and health, the investigation focused on the employees.

This waterpark measures approximately 80,000 square feet, and has a maximum occupancy of 3,746 persons. It contains 11 waterslides, two activity pools, two hot tubs, a wave pool, a leisure river, a four-story interactive play system, and several features that splash, spray, and aerate large amounts of water. Water flows by gravity through the main drains and gutter systems from the pool into designated surge tanks. The water is pumped out of the surge tank and filtered. An automated chemical controller tests and adjusts the water's pH and chlorine concentration as needed by adding a sodium hypochlorite solution (to disinfect) and sulfuric acid (for pH adjustment).

NIOSH investigators tested pool water for pH, microbials, sulfites and sulfates, and free and total chlorine and reviewed facility plans to assess water and ventilation system designs. Endotoxin were also tested for in air and

water. To assess the effect of the number of occupants in the pools (bather load), NIOSH investigators collected samples of air in several deck areas to test for trichloramine concentrations on high (more than 1,000 guests) and low bather load days (fewer than 100 guests) as approximated by hotel occupancy.

NIOSH investigators also conducted a survey of lifeguards working inside the waterpark (exposed) and hotel employees working outside the waterpark (unexposed). All participants filled out an initial questionnaire concerning demographics, work and medical history, and work-related symptoms occurring within the last month. Symptoms were considered work-related if they occurred on work days and improved on days off work. The following findings were noted:

From the medical assessment:

- Lifeguards had more work-related symptoms than unexposed employees.
- Lifeguards had more work-related cough and eye irritation on days when the number of people using the indoor pool area was high.

From the industrial hygiene assessment:

- Trichloramine concentrations were similar to those found in other indoor swimming pool studies, and concentrations at some pools were at levels reported to cause mucous membrane irritation.
- Air endotoxin were found at concentrations that have been associated with cough and fever.
- No fecal contamination, Legionella, mycobacteria, or sulfites were found in the pool water.

From the ventilation assessment:

- The ventilation system design may not have provided adequate air movement and distribution to adequately capture and remove air contaminants at the pool and deck level. Because all facilities are unique, ventilation system design should be evaluated case-by-case.

From the water system assessment:

- Water chemistry results met state and local standards.
- Spray feature piping drew water prior to the filtration and treatment cycle.

Recommendations

Below are specific steps/practices that waterpark/pool managers, designers, and public health officials can consider and/

or adopt to eliminate or minimize exposure to DBPs and endotoxin and reduce respiratory, skin, and mucous membrane irritation potentially related to these exposures.

Patron and employee education:

- Provide education and training to employees on recognizing the symptoms and signs of eye and respiratory irritation, skin rash, and asthma that may be attributed to DBP exposures.
- Encourage employees to report symptoms to management.
- Encourage patrons to shower before entering and after leaving the pool area.
- Encourage children to take frequent bathroom breaks to decrease the amount of nitrogenous waste released into pool water [Dziuban et al. 2006].

Water chemistry considerations:

- Keep combined chlorine levels as low as possible and continue to maintain water chemistry within recommended guidelines.
- Assess water system treatment design, such as ensuring that spray features draw water that has been adequately filtered and treated.
- Allow water to drain out of spray features during periods of disuse because research has shown that microbials can amplify in them overnight [Rose et al. 1998].
- Reduce aerosolization of potential contaminants by using nozzles that produce larger droplets and reduce spray feature cycle times.

Ventilation considerations:

- Place supply and return ducts in locations that allow the ventilation systems to provide enough air movement and remove contaminants properly.

Follow Up

Waterpark management made extensive changes to their ventilation system including, adding additional supply diffusers and lowering return air vents closer to deck level and aerosolizing spray features. The air handling units'

volume of airflow was increased, and ductwork changes were made to increase air movement to the front and back areas of the waterpark. A full year after changes were made, the county health department shared that no further chloramine-related symptoms had been reported.

Acknowledgments

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To read the full HHE report, visit the following Web site: <http://www.cdc.gov/niosh/hhe/reports/pdfs/2007-0163-3062.pdf>

References

- Dziuban EJ, Liang JL, Craun GF, Hill V, Yu PA, Painter J, Moore MR, Calderon RL, Roy SL, Beach MJ [2006]. Surveillance for waterborne-disease outbreaks associated with recreational water—United States, 2003–2004. *MMWR* 55(SS12):1–2.
- Gunkel K, Jessen HJ [1988]. The problem of urea in bathing water. *Z Gesamte Hyg* 34(4):248–224.
- Hery M, Hecht G, Gerber JM, Gendre JC, Hubert G, Rebuffaud J. [1995]. Exposure to chloramines in the atmosphere of indoor swimming pools. *Ann Occup Hyg* 39(4):427–443.
- Massin N, Bohadana AB, Wild P, Héry M, Toamain JP, Hubert G [1998]. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. *Occup Environ Med* 55(4):258–263.
- Rose CS, Martyny JW, Newman LS, Milton DK, Talmadge EK, Beebe JL, McCammon JB, Hoffman RE, Kreiss K [1998]. “Lifeguard lung”: endemic granulomatous pneumonitis in an indoor swimming pool. *Am J Public Health* 88(12):1795–1800.
- WHO [2006]. Guidelines for safe recreational water environments. Volume 2, Swimming pools and similar environments. Geneva, Switzerland, World Health Organization.

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